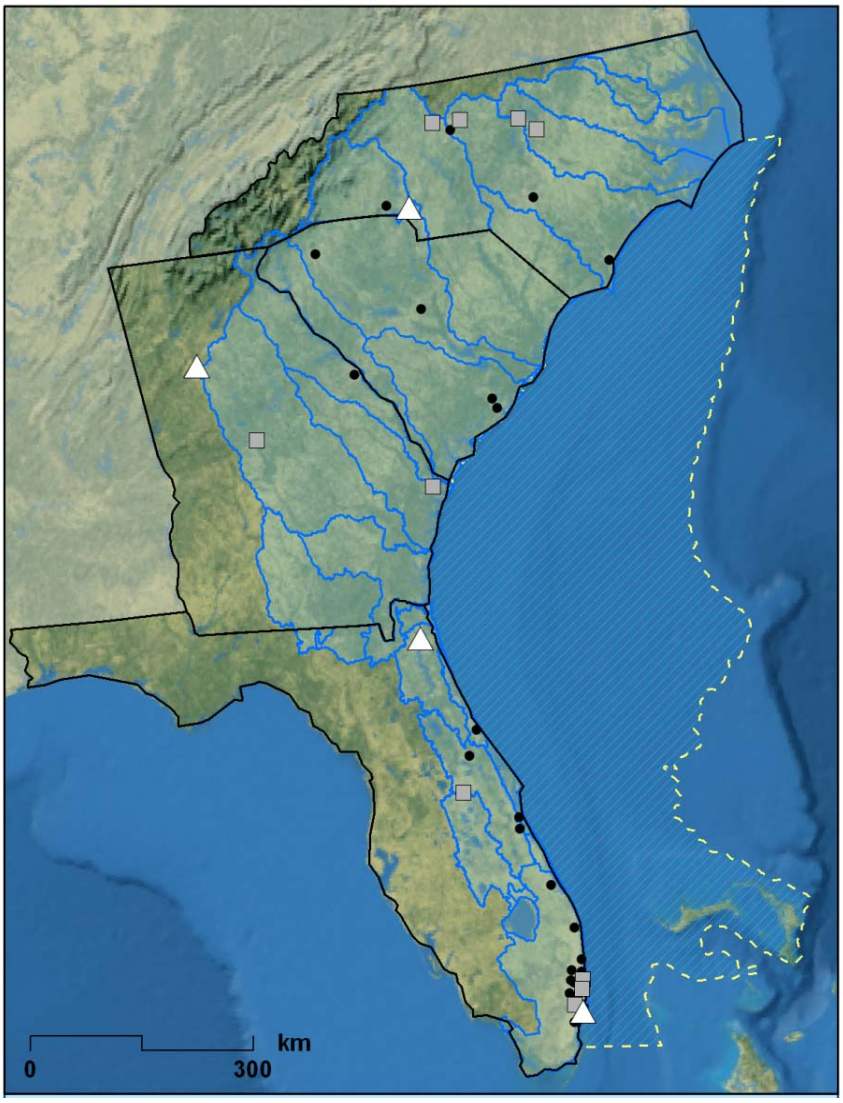
South Atlantic Regional Research Plan



April 2010

January 2011 revision

NOAA

Sea Grant North Carolina

Sea Grant S.C. Sea Grant Consortium

Sea Grant Georgia

Sea Grant Florida

GCRC Georgia Coastal Research Council

On the cover: The southeastern Atlantic region of the United States, which runs from North Carolina along the east coast to the tip of Florida. Cities with populations greater than 250,000 denoted by white triangles, those with populations between 100,000 and 250,000 denoted with grey squares, and those with populations between 50,000 and 100,000 denoted with filled circles. Blue lines indicate coastal watershed boundaries (based on U.S. Geological Survey Hydrologic Unit Codes). The boundary of the "Southeast Large Marine Ecosystem" is outlined in yellow. (Imagery courtesy of Natural Earth, U.S. Department of the Interior, National Park Service.)

Suggested citation: C. Laporte, M. Alber, D. Bryant, M. R. DeVoe, K. Havens, C. Hopkinson, S. Rebach, D. Sanger, M. Spranger, and M. Voiland. 2010. (rev. 2011). South Atlantic Regional Research Plan. Georgia Coastal Research Council. University of Georgia, Athens, GA. 29 pp. (http://www.gcrc.uga.edu/SARRP/Documents/SARRP_ResearchPlan_2010.pdf)

About the Georgia Coastal Research Council: The Georgia Coastal Research Council (GCRC) provides mechanisms for improved scientific exchange between coastal scientists and decision makers, and promotes the incorporation of best-available scientific information into State and local resource management. The Council is not a policy organization, but rather seeks to provide unbiased, objective information about scientific issues. For more information please contact us at gcrc@uga.edu or see our website at http://www.gcrc.uga.edu.

Table of Contents

South Atlantic Regional Research Plan

Introduction

The **South Atlantic Regional Research Project** (SARRP, http://www.gcrc.uga.edu/sarrp.htm**)** is a regional, multi-agency project to develop a coordinated coastal and ocean research plan for the southeastern United States. The project's goals are to identify regional priority research needs and foster partnerships to address those priorities. SARRP's geographic scope spans the southeastern U.S. coast, from the northern border of North Carolina to the southern tip of Florida at Florida Bay. This plan benefited from and is intended for use by all federal, regional, state and academic partners. The NOAA National Sea Grant College Program Office funded the development of the plan through the four Sea Grant Programs in our region (NC[1], SC[2], GA[3] and FL[4]) in conjunction with the Georgia Coastal Research Council (GCRC).[5] SARRP is operating in concert with similar projects in Sea Grant regions across the U.S. and Insular Pacific.[6]

Background

Congress provided the impetus for SARRP through the Oceans Act of 2000, which recognized the importance of the ocean, coasts, and Great Lakes to the well-being, productivity, economy and security of the United States. This legislation created the U.S. Commission on Ocean Policy[7] to review the nation's current ocean "policies" and make recommendations for the future. The Commission generated governing structures that include the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology (JSOST) and the Subcommittee on Integrated Management of Ocean Resources (SIMOR). SIMOR's original work plan specified "SIMOR and JSOST, working with NOAA Sea Grant, will seek to implement an interagency approach to establishing regional science planning efforts that are designed to support regional management activities for all regions of the country."[8] This echoed a similar sentiment from the Pew Oceans Commission (2003) that had also called for regional ocean governance.

The emphasis on regional management continues into the Obama administration. The Interagency Ocean Policy Task Force, created in 2009 and led by the White House Council on Environmental Quality (CEQ), developed recommendations that address improving coordination and collaboration among Federal, State, Tribal, and local authorities, regarding ocean policies and planning. In July 2010, the CEQ released their Final Recommendations[9], specifying the

[1] http://www.ncseagrant.org/
[2] http://www.scseagrant.org/
[3] http://www.marsci.uga.edu/gaseagrant/
[4] http://www.flseagrant.org/
[5] Georgia Coastal Research Council website http://www.gcrc.uga.edu/
[6] National Sea Grant Regional Initiative website http://www.seagrant.noaa.gov/regional/
[7] U.S. Commission on Ocean Policy expired in 2004 http://oceancommission.gov/
[8] SIMOR website http://water.epa.gov/type/oceb/simor.cfm Work Plan pdf no longer available.
[9] National Ocean Council website http://www.whitehouse.gov/files/documents/OPTF_FinalRecs.pdf

creation of the National Ocean Council, and regional planning bodies for each of nine coastal regions (comprised of federal, state, and tribal representatives) to develop regional goals and objectives. The White House issued a concurrent Executive Order, "Stewardship of the Ocean, Our Coasts and the Great Lakes" (Obama 2010), adopting the CEQ's recommendations and directing executive agencies to implement our Nation's first ever National Ocean Policy, under the guidance of the National Ocean Council.

The CEQ's final report and our National Ocean Policy underscore the importance of using a regional framework in coastal and ocean planning and management. For example, the CEQ recommendations specify the development of a Governance Coordinating Committee, which will have representation from existing Regional Ocean Partnerships (ROP) such as our region's Governors' South Atlantic Alliance (the ROP representing North Carolina, South Carolina, Georgia and Florida).[10] Significantly, the regional planning bodies are tasked with facilitating Coastal and Marine Spatial Planning (CMSP) in each region. CMSP is a planning tool described by the National Ocean Council as "a comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses of ocean, coastal, and Great Lakes areas. In practical terms, CMSP provides a public policy process for society to better determine how these areas are sustainably used and protected – now and for future generations."[11]

These efforts, and related regional approaches, are among the prime targets for the SARRP results; with its timely interagency, regional process to identify research priorities, SARRP and its academic and research partners can significantly advance our region's progress towards meeting the Nation's coastal and ocean stewardship needs, based on sound science.

SARRP is also working in close partnership with the Governor's South Atlantic Alliance (SAA), whose Mission is to "implement science-based policies and solutions that enhance and protect the value of coastal and ocean resources of the southeastern United States to support the region's culture and economy now and for future generations." The SAA has identified four priority issues (Healthy Ecosystems, Working Waterfronts, Clean Coastal and Ocean Waters, and Disaster-Resilient Communities) for their activities. We have used these issue area categories to organize SARRP results in order to facilitate synergism between these two efforts. However, it is important to note that "binning" of research issues in this way did not drive the creation of the SARRP plan. We also recognize that there are linkages among categories. For example, Clean Coastal and Ocean Water is an essential condition for Healthy Ecosystems; and both Working Waterfronts and Disaster-Resilient Communities have implications for all the other groups. As we move towards implementation there may be other relevant ways to align the region's research priorities.

Biogeography

The SARRP region ranges from the coastal areas of Currituck Sound in North Carolina to the Florida Bay in Florida, starting from the coastal watersheds and reaching out to the edge of the

[10] South Atlantic Alliance website http://www.southatlanticalliance.org/
[11] http://www.msp.noaa.gov/

continental shelf (see cover Figure). It comprises the major portion of NOAA's "Southeast US Continental Shelf Large Marine Ecosystem"[12] and the broad coastal plain in this region is bordered by an almost continuous strip of barrier islands interspersed with tidal inlets and estuaries.

Three general geographical areas can be discriminated in the region: the sounds of North Carolina; the alternating series of riverine and ocean-dominated estuaries of South Carolina, Georgia, and northeastern Florida; and the subtropical bar-built estuaries of the Florida southeastern coast (Dame et al. 2000). The coastal zone encompasses upland (mainland, barrier islands, marsh hammocks), intertidal (fresh, brackish and salt marsh) and submerged (river, tidal creek, estuary, continental shelf) habitats. Sea grasses are common in the northern and southern-most systems, while intertidal salt marshes reach their greatest extent and productivity in South Carolina and Georgia. Commercially important species in the region include clams, blue crab, shrimp, groupers, and snappers, whereas recreationally important species include black sea bass, bluefish, dolphinfish, king mackerel, red drum, sharks, sheepshead, Spanish mackerel, spot/Atlantic croaker, and spotted seatrout (NOAA-NMFS 2006). Finfish dominate the commercial catches in North Carolina and Florida, whereas the greater proportion of catch in South Carolina and Georgia is shrimp and crabs.

Regional Challenges

Healthy, well-functioning ecosystems provide the foundation for the high quality of life offered by our coastal region. Clean and abundant freshwater, productive estuaries, sustainable fisheries, viable recreational beaches and critical wildlife habitat have significant cultural and economic values for residents and tourists alike. The good news is that the southeastern coastal region is doing relatively well in comparison with most other regions of the country, as indicated by the Environmental Protection Agency's most recent coastal water quality ratings. The 2008 *National Coastal Condition Report III*[13] rated overall coastal condition in the southeastern U.S. in the "high end" of the fair range, with a score of 3.6 (a rating of 5 being the highest), whereas the overall condition of U.S. coastal waters is rated in the "low end" of the fair range (2.8 with inclusion of South-central Alaska and Hawaii, 2.3 if data from those regions is excluded). The water quality, sediment quality, and coastal habitat indices for the region were rated fair; the benthic index was rated good; and the fish tissue contaminants index was rated good to fair.

Unfortunately, as the human population increases in the southeastern coastal region the resources come under increased pressure. The region has seen unprecedented human population growth over the last several decades. Between 1980 and 2003, coastal counties of the South Atlantic region showed the largest rate of population increase (58%) of any coastal region in the coterminous United States. Most of this growth occurred in Florida, which saw a population increase of 7.1 million people, or 75%, during this time period (EPA 2008). Population growth is coupled to changes in land use, increased demand for water supply and wastewater disposal, and increased demand for coastal resources. This growth, along with increased tourism, has dramatically accelerated economic investment within the region. It has also placed enormous pressure on coastal resources, watersheds, and the adjacent coastal ocean.

---

[12] National Oceanic and Atmospheric Administration "Large Marine Ecosystem" website http://www.lme.noaa.gov/

[13] Environmental Protection Agency. Wash. DC. 2008. *National Coastal Condition Report III*, pp. 38-40. http://www.epa.gov/owow/oceans/nccr3/downloads.html

The fisheries in the region are also under increasing pressure. Five of the fish stocks managed by the South Atlantic Fisheries Management Council are classified as overfished (pink shrimp, snowy grouper, black sea bass, red porgy and red snapper), and eight are subject to overfishing (vermilion snapper, snowy grouper, red grouper, black grouper, warsaw grouper, gag, speckled hind, and tilefish).[14] The NOAA National Marine Fisheries Service recently issued an order to close commercial harvesting and severely limit recreational takings for the snapper-grouper fishery (which includes over 50 fish species).[15] This has been coupled to a decrease in revenue from commercial fishing over time: Environment North Carolina Research and Policy Center calculated a decline in ex vessel sales from approximately $276 million dollars in 1996 to $150 million in 2006 (in 2006 dollars).[16]

Another series of critical challenges are related to climate change impacts, which may cause ecological thresholds to be crossed, thus disturbing or disrupting ecosystems that provide numerous important living marine resources and services with high economic and cultural value in the southeast. For example, sea-level rise and extreme storm and rainfall events are serious threats to the region because of its low and relatively flat geomorphology. Rising sea levels will "drown" marshes that cannot accrete and migrate fast enough to keep pace, drive salty surface water further inland, and increase the extent of coastal flooding of portions of cities and developed properties during storm surges from Atlantic hurricanes and Nor'easters. Ocean acidification, occurring from the absorption of increasing levels of carbon dioxide (CO_2) in the atmosphere, has major implications for carbonate-based ecosystems such as oyster beds and coral reefs. The resulting lowered ocean pH reduces the availability of carbonate ions that play a role in the shell formation for many important organisms including corals, plankton and shellfish. In the southeast, acidification could result in potentially significant impacts on biodiversity, particularly off the coast of Florida where coral reefs are found. Changes in ocean temperatures may also lead to shifts in ranges for sessile species and migration patterns for migratory or pelagic species, including important fisheries.

Despite these and other pressures, the southeastern region is fortunate to still have broad areas of relatively healthy coastal habitat, and there is much to protect. Unlike some other areas of the country that are more developed, the opportunity exists to make scientifically-sound coastal management choices that effectively balance economic sustainability, and the protection of human health and resource conservation against the management challenges in the region. Our goal is to provide information that can be used to manage coastal and marine resources in order to meet the region's environmental, economic, and societal needs.

---

[14] Department of Commerce, NOAA, Fisheries Service, *Fish Stock Sustainability Index (FSSI) 2009 Quarter 4 Update* http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

[15] Department of Commerce, NOAA, Fisheries *of the Caribbean, Gulf of Mexico, and South Atlantic; Snapper- Grouper Fishery of the South Atlantic; Red Snapper Closure*. 50 CFR Part 622 [Docket No. 090508900–91414–02] RIN 0648–AX75 http://www.safmc.net/Portals/6/Library/FMP/SnapGroup/RSInterimRuleFRN120409.pdf

[16] Environment North Carolina Research and Policy Center. 2007. *Net loss - Overfishing off the S. Atlantic Coast*. Raleigh, NC. 18pp. http://cdn.publicinterestnetwork.org/assets/kOfAZmOhRpSbO7uC1aw8ew/Net-Loss.pdf

Methods

From its inception, the South Atlantic Regional Research Project has been a true regional collaboration. Development of the SARRP plan was coordinated by the Georgia Coastal Research Council under the direction of an Organizing Committee consisting of representation from the four SARRP Sea Grant programs (Appendix A). A Regional Advisory Group (Appendix B) is in place to help guide the project and ensure that it is well coordinated with other regional efforts. A larger Strategy Team, comprised of the Regional Advisory Group along with additional coastal experts from agencies, research and educational institutions throughout the southeast (Appendix C), worked together to identify priority research areas. There is also significant overlap in membership between the SARRP Regional Advisory Group, the Strategy Team, and the Executive Planning Team of the Governors' South Atlantic Alliance.

The process used to produce the SARRP plan involved gathering input from existing documents, regional experts, and a broad stakeholder survey. The results of these efforts were used to develop a draft framework that aligned the SARPP efforts with both the Ocean Research Priorities Plan (ORPP)[17] and the broad themes identified by the South Atlantic Alliance. This information was then used by the Strategy Team to identify high priority research needs for the region. Each of these steps is described in more detail below.

Needs Assessment

An initial *Needs Assessment*[18] was conducted, based on examination of over 170 research plans and related documents developed at national, international and regional scales (see *Compilation of Documents Examined*).[19] We organized over 100 categories of "research needs" identified in these documents into a DPSIR (Driver-Pressure-State-Impact-Response) framework, which assumes cause-effect relationships between interacting components of social, economic, and environmental systems. The DPSIR framework is used extensively by the United Nations (UN) Environment Programme, the UN Food and Agricultural Organization, the European Union, and others (UNESCO 2006).

Regional Advisory Group

SARPP's Regional Advisory Group, with high-level representation from state, regional and federal interests in the southeastern states, held its initial meeting in December 2007 to provide feedback on the *Needs Assessment* and guidance on gathering stakeholder input. The group continued to contribute throughout the process via e-mail and phone calls, and convened again, along with additional coastal experts, for the Strategy Team Workshop (see below for details).

---

[17] National Science and Technology Council, Joint Subcommittee on Ocean Science and Technology. 2007. *"Charting the Course for Ocean Science in the United States for the Next Decade: An Ocean Research Priorities Plan and Implementation Strategy."* Washington, DC. 101pp.

[18] South Atlantic Regional Research Project. *Needs Assessment (rev.)*. 2009**.** http://www.gcrc.uga.edu/SARRP/Documents/NeedsAssessment_ju07.pdf

[19] South Atlantic Regional Research Project. *Compilation of Documents Examined.* 2007. http://www.gcrc.uga.edu/SARRP/Documents/SARRPAssessmentDocsAppendixA_April09.pdf

Stakeholder Survey

A stakeholder survey was conducted in the summer of 2008 to identify important coastal resource issues within the region. The web-based survey focused on the Impacts identified using the DPSIR framework in the *Needs Assessment* and was hosted on SurveyMonkey.com from August 25 through September 30, 2008. Over 4,000 copies were distributed directly, with additional distribution through open access on the web. Of the 552 respondents who began the survey, 524 finished, resulting in a completion rate of 95%. There were 182 respondents from Florida, 120 from Georgia, 114 from North Carolina and 95 from South Carolina. The *Stakeholder Survey Summary* [20] can be found on the SARRP website.

Strategy Team Workshop

In April 2009, SARRP convened a Strategy Team Workshop. Workshop participants used the information gathered in the *Needs Assessment* and *Stakeholder Survey* as the launching point for identifying top research priorities for each of the four priority themes of the South Atlantic Alliance (Healthy Ecosystems, Working Waterfronts, Clean Coastal and Ocean Waters, and Disaster-Resilient Communities). The Team was tasked with identifying priority issues that are relevant to the region, management-critical, timely, tractable, and offer value for societal applications. The priority research needs that received the highest number of votes at the Strategy Team Workshop were used to develop the regional research priorities presented in the Results section below. A summary of the Strategy Team Workshop can be found on SARRP's website.[21]

[20] South Atlantic Regional Research Project. *Stakeholder Survey Summary*. 2008. http://www.gcrc.uga.edu/SARRP/Documents/SARRPSurveySummary.pdf

[21] South Atlantic Regional Research Project. *Strategy Team Workshop Report*. 2009. http://www.gcrc.uga.edu/SARRP/Documents/SARRPStrategyTeamWorkshop09Report2.pdf

Results

Healthy Ecosystems

The southeastern U.S. coast consists of a mosaic of habitats. The relatively flat coastal plain is bisected by multiple rivers and creeks that drain into estuaries and sounds. Freshwater swamps along the edges of the upstream reaches of these waterways give way to intertidal marshes that range from freshwater marshes (dominated by wild rice) to first brackish and then the more familiar salt marshes along the coast (dominated by salt marsh cord grass). Further south, in the warmer waters of Florida, the marshes shift to mangrove habitat. Although they are absent in the central part of the region (South Carolina and Georgia), sea grasses can be found growing in the clearer waters of the estuaries and sounds of North Carolina (where eelgrass predominates) and Florida (where turtle grass dominates). Tidal creeks, sea grass beds, intertidal marshes and mangroves all serve as critical spawning, nursery and refuge habitats for early life stages of important marine species. These areas also contain both subtidal and intertidal oyster reefs, which provide additional habitat, improve water quality through removal of suspended material, and serve to help stabilize creek banks (Beck et al. 2009).

A chain of barrier islands stretches along the coast. These islands and coastal hammocks are vegetated by maritime forest, which can also be found on the mainland (at least in undeveloped areas). Dunes and sandy beaches run along the outer edge of the barrier islands, whereas their inner edges provide protection for marshes or mangroves. Further offshore, the broad continental shelf off the southeastern U.S. coast provides shallow habitats including soft sediment, hard bottoms, rocky outcrops, and corals, which are home to fishes and other marine life. This landscape is home to diverse and varied wildlife, including the region's key commercially and recreationally important species such as fish, shrimp and crabs as well as the smaller organisms on which they feed. Equally important are many non-game wildlife species that reside or migrate throughout the region, some of which are listed as threatened or endangered. Shore birds, sea turtles, and a host of marine mammals (e.g., northern right whales, pygmy sperm whales, Atlantic bottlenose dolphins, and manatees) can be found in these ecosystems.

These ecosystems face significant pressure. Their degradation has implications for many ecological services upon which humans depend, including storm surge protection, water purification, and fisheries harvest. Impacts identified as high priority in the SARRP *Stakeholder Survey* included concerns about tidal and non-tidal wetlands (including degradation and loss of salt marshes, fresh and brackish wetlands); loss of commercially and recreationally important fisheries (including crabs, shrimp, shellfish, coral, and finfish); potential loss of endangered and threatened species (including sea turtles, marine mammals, fish, sea grasses, birds and coastal plants); loss of hard or rocky formations supporting sponges, corals, and other invertebrates on the ocean floor; effects of human actions on marine life (food web interactions, community dynamics, bioaccumulation); and effects of aquatic invasive and non-native species on resident populations. An additional, related impact (acoustic effects on marine life by marine operations) was identified in the open response section of the survey. A similar set of impacts was identified in the SARRP *Needs Assessment*, which included calls for studies of marsh dieback, the functional role of estuarine habitats and embayments, ecosystem-based management, and habitat and species-specific research required for fishery management plans.

The high priority research topics related to Healthy Ecosystems are[22]:

- **Develop detailed maps of coastal habitats and species distributions in the South Atlantic Region** – Maps showing the distribution of organisms and coastal habitat types are an important first step in developing marine management and spatial plans.

    - **Habitat maps** – Information on the location of important submerged (e.g., hard bottoms, coral reefs), transitional (e.g., tidal creeks, oyster reefs), intertidal (e.g., marshes, mangroves, beaches) and upland habitats (e.g., maritime forest) are essential for helping to identify areas suitable for different activities and reducing potential conflicts among users. Habitat maps can also serve as baselines against which to evaluate change and can be useful for managing and protecting specific habitats. They can also be used to define and refine essential fish habitat designations. The Nature Conservancy has produced an ecoregional assessment of the Carolinian region that includes some of this information (e.g., shellfish beds, shoreline types)[23]. There are also habitat maps (e.g., sea grasses, corals) developed by the South Atlantic Fisheries Management Council (SAFMC).[24] SAFMC identified a high priority need for improved mapping of subtidal areas (near-shore, mid-shelf, shelf edge, and deep water).

    - **Species distributions** – Although there is information on the distribution of managed fish stocks, we do not have comprehensive information on other living marine resources in the region. There is a need to collect coordinated data on the distribution and abundance of organisms such as invertebrates, seabirds, and marine mammals, such as is being done on a global scale by the Census of Marine Life (an international initiative to assess the diversity, distribution, and abundance of life in the ocean).[25] This type of information can serve as a baseline and help identify trends in exotic or invasive species (e.g., green mussels, lionfish) and in tracking species shifts (e.g., due to climate change). It can also be useful for Coastal and Marine Spatial Planning (see Discussion).

- **Assess the impacts of climate change on coastal habitats and species** – Increases in the rate of sea-level rise, changes in precipitation, increases in temperature, decreases in pH, and increases in the severity of major storms will affect organisms as well as coastal habitats. Mechanistic studies are needed to evaluate how different aspects of climate change will affect southeastern ecosystems (e.g., how do changes in temperature affect rates of nutrient cycling or the virulence of pathogens? how sensitive are deepwater corals to changes in pH?). Models are also needed to understand and predict effects at a regional scale (e.g., which areas are most vulnerable to increased storm surge? how will changes in sea level affect benthic and pelagic habitats?). This needs to be understood

[22] Note that these were all identified as high priority needs and are presented without further ranking.
[23] 2005. De Blieu, J. M. Beck, D. Dorfman, P. Ertel. "*Conservation in the Carolinian Ecoregion, An Ecoregional Assessment"* The Nature Conservancy, Arlington, VA.
http://www.nature.org/wherewework/northamerica/states/southcarolina/marine/art28615.html
[24] 1998. South Atlantic Fisheries Management Council. Habitat Plan for S. Atlantic Region. Charleston, SC. 457 pp plus appendices A-S.
[25] Census of Marine Life – website- http://www.coml.org/

against the natural backdrop of environmental variability (e.g., what types of fluctuations are observed in marine populations?). In addition, because climate change is only one ramification of human activity, it is essential to separate climate effects from other drivers of change, such as land use and development changes and increasing populations in coastal watersheds.

- **Evaluate the effectiveness of ecological restoration** – Ecological restoration of coastal habitats in the southeast ranges from large-scale efforts to alter/restore flow in the Florida Everglades to smaller scale projects such as the re-establishment of subtidal and intertidal oyster reefs. There is also interest in the use of living shorelines (e.g., trapping sediment to allow colonization by marsh plants) as a way to help control erosion. Studies are needed to evaluate the effectiveness of these approaches, as well as their benefits. Studies are also needed to evaluate wetland restoration projects. For example, does a former rice field with restored tidal flow provide the same ecosystem functions as an undisturbed wetland? Criteria also need to be developed for use in measuring restoration success. Finally, a census of coastal water control structures, such as causeways and pipes limiting water flow, is needed to evaluate potential for retrofitting or restoring ecological function of marshes as a mitigation tool.

- **Understand linkages and interdependencies among ecosystems** – The vitality of specific habitats and ecosystems depends on the quality and health of the larger systems of which they are a component. For instance, an oyster reef is affected by the conditions of the water and the food resources transported by the tides. Likewise, pelagic organisms are dependent on habitat and organic matter provided by adjacent salt marshes. We must understand the importance of these linkages to evaluate how various stressors, such as changes in water quality or sea-level rise, might affect not only individual components but also adjacent ecosystems. A linkage approach can also be useful for exploring regional, larger system dynamics. For example, how might a reduction in freshwater inflow to an estuary affect the extent of tidal freshwater wetlands, and how might that in turn affect striped bass populations that move between these areas and systems hundreds of miles away? It would also be useful to develop conceptual models that identify key linkages between ecosystems, as well as bottlenecks and data gaps.

- **Improve and expand Ecosystem-based management models for the southeastern region** – Ecosystem-based management (EBM) is an approach that considers a resource in the context of its environment, incorporating information on habitat, life history, trophic structure, and environmental conditions. There is a need to collect data that inform ecological models (e.g., information on diet, primary and secondary production and species interactions), particularly for important fisheries (e.g., gag grouper). EBM can also be used for other applications such as place-based management and to evaluate broader questions, such as the cumulative impact of human activities on marine ecosystems.

- **Quantify the relative importance of fishing and other factors on abundances of fish stocks** – Fish stocks can decline as the result of overfishing, but they can also be affected by other factors such as habitat loss, variations in freshwater inflow, water quality, climate change, predator-prey interactions or disease. For example, blue crabs are

subject to parasitic infection by the dinoflagellate *Hematodinium* and oysters are affected by the parasite *Perkinsus*. Other declines may be the result of reduced habitat availability (e.g., deep water coral reef loss), or the potential effects of pharmaceuticals and endocrine disrupters on reproduction. Studies are needed to evaluate the relative importance of these factors for different organisms, particularly for fish classified by the National Marine Fisheries Service as overfished in the southeast region (red snapper, snowy grouper, pink shrimp, black sea bass, red porgy). Models that incorporate natural variability in fishery stocks are needed to fully understand spawning-recruitment relationships, particularly for estuarine species. This type of information can be used in conjunction with fishery data to develop metrics that reflect the health of representative species and their ecosystems. For example, can we develop a composite index that reflects the overall fisheries status of broad regions such as the outer continental shelf or salt marsh estuaries?

- **Develop sustainable harvesting and seafood culture techniques** – As fishery stocks decline and demand for seafood increases, it will be important to wisely utilize our resources. This includes creating and using sustainable fishing techniques that minimize impacts to habitats and nontargeted species. Additionally, culture of selected shellfish (hard clams, oysters) and fish species (red drum, cobia, southern flounder, black sea bass, red porgy), should be studied to help reduce pressure on wild stocks.

- **Examine habitat and population recovery patterns following physical disturbances** – Disturbances caused by natural processes and events (e.g., storms) or by human activity (e.g., dredging) can affect both organisms and the environment. The trajectory of recovery from these events is not clear. There is particular interest in understanding the effects of small-scale disturbances on salt marshes, such as those caused directly from boat wakes, for example, or by the accumulation of wrack against pilings or other structures that appears to smother marsh plants.

- **Develop water budgets and minimum flow estimates for coastal systems** – Human activities can affect the amount of freshwater delivery to the coast either directly, (via flow diversions, channel modifications, or reservoirs and dams); or indirectly, (via changes in land cover). Overlaid on this are the potential effects of climate change (e.g. precipitation patterns), which will affect surface water runoff, groundwater inputs and, in conjunction with sea-level rise, salt water intrusion into local aquifers. Understanding the effects of altered water flow requires information on the sources of both fresh and saltwater to a system as well as the amount of time that it remains there (residence time). Example questions that need to be answered include: How will the operation of a dam affect the salinity distribution in an estuary? How will changes in overland runoff associated with development affect groundwater infiltration? Do changes in groundwater flow affect salt marsh dieback events? Which tidal creeks are most sensitive to changes in inflow from uplands? What are the minimum flow requirements for different coastal ecosystems of the southeast region?

Working Waterfronts

The concept of "Working Waterfronts" as it is employed in this project includes the marine operations of the coastal economy, from traditional fishing communities, to marine businesses, to tourism and recreation, and to ports. It also includes military operations, offshore energy development, commercial fishing, as well as small-scale residential developments, docks and marinas, golf courses, destination beaches, and ecotourism operations. Land-based operations and infrastructure, such as roads and railroads required to support these activities, are also part of our concept of working waterfronts.

Ports and their associated infrastructure (e.g., railroads, highways) comprise a major sector of marine operations. The region's 14 ports handled over 133,053,000 tons of cargo in 2007 (most recent compiled data).[26] The majority of that cargo (105,000,000 tons) passed through the four major ports of Savannah GA, Jacksonville FL, Charleston SC and Port Everglades FL. In addition, more than a dozen major coastal military installations are spread throughout the region, including the Camp LeJeune Marine Base (NC), the Charleston Air Force Base (SC), the Fort Stewart Army Base (GA), and the Jacksonville Naval Air Station (FL). The U.S. Coast Guard also has major bases in all southeastern states except Georgia.

Both recreational and commercial fishing are important contributors to the region's coastal economy. While it is difficult to assess the physical infrastructure footprint of fisheries, commercial fishing operations landed 116 million pounds of catch in the southeastern U.S. in 2006, worth approximately $141 million (NOAA 2006). The recreational fishing industry is a very large sector, with more than 75,000 jobs associated with saltwater recreational fishing in 2006 (including all of Florida).[27] The total number of saltwater anglers in the southeast increased 55% between 1997 and 2006, with the greatest number in eastern Florida (2.6 million) and the fewest in Georgia (219,000). In 2006, residents of the region spent $563 million on all trip-related expenses whereas non-residents (tourists) spent $760 million. The cumulative sales impact of this activity in the region was approximately $9.9 billion (NOAA 2006).

One of the most important components of the coastal economy in the southeastern U.S. is tourism, which is fueled by relatively mild weather, an attractive coastline, and numerous recreational opportunities. In 2007, coastal-related tourism in Florida contributed $10.7 billion, accounting for 69.5% of the state's "ocean Gross Domestic Product", (an economic metric comprised of revenue from six sectors: marine transportation, tourism & recreation, living marine resources, marine construction, ship & boat building, and mineral extraction).[28] In South Carolina, coastal golf courses alone account for a majority of the golf-course industry's $1 billion contribution to the state's economy (SCDPRT and SCGCOA 2002). Tourism is also very important along the coasts of Georgia and North Carolina.

Overlaid on these various uses of the waterfront is the region's unprecedented population growth over the last several decades. This growth, along with increased tourism, continues to dramatically accelerate economic investments in the region, but it also has the potential to

[26] Sherman, Rex. Research Director, American Association of Ports Authorities. 2009. Personal Communication.
[27] American Sportfishing Association. 2006. *Economic Impact of Saltwater Fishing by State in 2006.* Alexandria, VA. http://www.asafishing.org/statistics/saleco_trends/2006ei_salt_state.htm
[28] National Ocean Economics Program. 2009. *State of the U.S. Ocean and Coastal Economies. Summaries of the Coastal States*. 62pp.

increase conflicts among users. Some of the more traditional users of the shore such as small-scale fishermen are experiencing loss of their fishing docks and public access, and some seafood processing facilities have been converted to marinas to serve high density residential development. Other potential users of coastal areas in the region are also emerging. For example, investors in the private sector are actively pursuing the development of non-renewable (e.g., oil and gas) and renewable (e.g., wind) energy sources in nearshore and offshore coastal waters.

Several effects of development and demographic changes on coastal economies and resource access were identified as high priority in the SARRP *Stakeholder Survey*, including: loss of viable fishing or other traditional livelihoods; decrease in public access to coastal waters, shores and beaches; bans on swimming and fishing; beach renourishment issues; and impacts of energy exploration and extraction activities. The SARRP *Needs Assessment* identified calls for studies on impacts of dam and impoundment construction; effects of the built environment, including seawalls, on beach processes; the impacts of docks and other structures on the marsh; and the introduction of invasive species by human marine activities.

The high priority research topics related to Working Waterfronts are[29]:

- **Assess current demographics and trends for working waterfronts** – It is difficult to get a complete picture of the different groups that comprise the working waterfronts domains along the southeastern U.S. coast. There is a need for an analysis of the region's changing demographics and the accompanying changes in employment, lifestyle, and recreation. Information on the population structure, ethnicities, and income levels and an analysis of the trends within different industries by county and state would be useful, along with an examination of the social implications of those trends. For example, how has the business footprint of the southeastern U.S. coastal zone changed over the past three decades? What traditional and existing working waterfront activities have been affected by changing demographics and population shifts? What are the implications of increased population density in terms of quality of life? How do changing demographics affect workplace literacy or emergency management programs?

- **Evaluate the impacts of human activities on working waterfronts** – There are numerous forces changing the nature of economic activities in the southeastern coastal zone. In-migration of retirees, increased tourism, and an accompanying demand for amenities such as marinas and golf courses are changing the nature of the working waterfront. As working waterfront properties increase in value, less economically competitive businesses (e.g., fish houses) are often displaced by more competitive enterprises (e.g., marinas). Research is needed to evaluate the societal and cultural effects of these changes. How do rising waterfront property values affect the southeastern shrimp fishery? How do changes in the real estate tax structure affect small businesses? What is the economic impact of different permitting policies for docks and setbacks? What approaches are available for communities to prevent and address the loss of culturally important, traditional activities?

[29] Note that these were all identified as high priority needs and are presented without further ranking.

- **Evaluate sustainable development techniques –** There is increasing interest in the use of green building design and other sustainable development techniques (e.g., low impact development, reinvestment in urban areas, enhancing public transportation) as ways to minimize the environmental effects of coastal development. However, it is not clear how well the various approaches work in comparison to standard practices. Studies are needed to evaluate and compare these alternative approaches. For instance, what is the efficacy of various methods for increasing infiltration to reduce stormwater runoff? How well do different types of buffers or stormwater ponds trap pollutants (and do these ponds serve as reservoirs for these pollutants and harmful algae)? Which dock designs minimize environmental impacts? Although studies of this kind have been done in other regions, their results are not always applicable to the warm temperatures and sandy soils of the southeast coastal plain.

- **Assess the impacts of energy extraction in the coastal zone** – Now that Congress has lifted its moratorium on drilling in the Atlantic region there is increasing interest in seismic exploration to determine the potential for oil and gas development in offshore waters. There is also strong interest in the potential for renewable energy sources (e.g., wind). The potential risks and benefits of these types of activities have not been adequately assessed. What are the onshore implications of offshore energy development to our coastal communities? (e.g., transmission lines, fabrication, hooking into the grid, cabling). What are the ecological risks and societal perspectives associated with offshore drilling, wind power, and other energy-related activities?

- **Develop methodologies for assessing coastal and oceanic Ecosystem Services** – Evaluating tradeoffs among development options requires an analysis of costs and benefits not only in terms of traditional economics but also in terms of natural resource valuations. The assessment of ecosystem services to evaluate options is relatively new and has the potential to help guide more sustainable development. We need to develop new and easier methods to value ecosystem services so that this approach can be tested. For example, can we use conceptual models to assess the benefits and losses related to different scenarios? This type of information can be used to help value services such as water purification and food web support, for example. It could also be useful for developing methods for siting infrastructure, minimizing environmental impacts while maximizing utility for marine operations and preserving important Ecosystem Services.

- **Evaluate the effectiveness of efforts to inform decision-making regarding coastal resources** – Providing scientific information about threats and opportunities relevant to coastal resources is often insufficient to inform decision-making. Social research is needed to determine how individuals and institutions actually make resource decisions, what the barriers are to improving science-based decision-making, what impediments prevent good science from fostering good decisions, and how and where to apply the results of scientific research to achieve the best societal response. These insights could help local municipalities, extension programs in each state, and regional partnerships, such as the Governors' South Atlantic Alliance (SAA), Southeast Coastal Ocean Observing Regional Association (SECOORA) and Center for Ocean Sciences Education – Southeast (COSEE-SE), to better achieve their goals.

Clean Coastal and Ocean Waters

Clean water is essential for healthy coastal and ocean resources. Pollutants in marine systems, in the form of pathogens, toxic materials, suspended solids, oxygen-consuming organic matter, and nutrients can have adverse effects on aquatic organisms and the amount and quality of habitat. Pollutants enter coastal waters primarily from land, so there is a large focus on upstream inputs, but they can also come from the atmosphere, the underlying sediments (particularly in cases of "legacy contaminants"), or even the coastal ocean. Some studies have suggested that plastic specks (from marine debris) in water and sediment can bond with highly toxic and pervasive pollutants, such as polychlorinated biphenyls (PCBs) and pesticides, which may be passed through the food chain (Arthur et al. 2009). Regardless of their source, pollutants can contaminate water and seafood, enhance the frequency of harmful algal blooms, increase hypoxic and anoxic events, and contribute to the loss of habitat. The condition of our coastal and ocean waters also affects fishing and shellfishing as well as other human uses of the coast, such as boating and swimming.

Although the southeastern U.S. coast is generally considered healthy in comparison to other regions of the country, there are emerging problems in the area. Indeed, symptoms of eutrophication have been documented in nearly half of the major southeastern estuaries, with future deterioration predicted (Bricker et al. 2007). In the recent National Coastal Condition Report (EPA 2008), 54% of the water quality index ratings in the southeastern coastal region were either fair or poor; and 59% of chlorophyll a concentrations were classified as fair. Research by Gutowski et al. (2008) has linked increases in the concentrations of chemical contaminants and bacteria in tidal creeks with increased development. Long-term observations at the Skidaway Institute of Oceanography show a long-term decrease in dissolved oxygen: summer surface water minimum % dissolved oxygen saturation declined from 80% to <60% between August 1986 and August 2004 (Verity et al. 2006). More recently, hypoxic events have been observed along the Grand Strand coastal region (in Long Bay) of South Carolina. Nuisance algal blooms (cyanobacteria, dinoflagellates and cryptomonads) also occur in the region, particularly in the more northern and southern extremes. Contaminants are also a problem: as of 2003, 100% of the southeastern coastal region was under fish consumption advisories, due primarily to mercury contamination, although there were also advisories issued for PCBs and dioxins (EPA 2008).

The SARRP *Stakeholder Survey* respondents selected the following as high priority impacts related to Clean Coastal and Ocean Waters: changes in water and sediment quality of near-shore waters, estuaries and tidal creeks; effects of chemicals on organisms, including toxins, contaminants (pesticides, herbicides, petroleum products), and hormones; and contaminated seafood. Additional, related impacts (saltwater intrusion in drinking water; human health issues such as pollutants causing red tide, odors, and respiratory illnesses; marine debris; and the impacts of altered water quality on organisms) were identified in the open section of the survey. The SARRP *Needs Assessment* called for studies on nutrient availability and cycling; ocean processes and dynamics involved in carbon cycling; the effects of upland land use and land cover change on estuaries; estuarine hypoxia, coastal hypoxia and harmful algal blooms; coastal development impacts on water quality; atmospheric deposition and water quality; and the need for a coastal circulation model.

The high priority research topics related to Clean Coastal and Ocean Waters are[30]:

- **Enhance environmental monitoring** – Monitoring coastal and ocean water provides useful information for a number of applications, ranging from providing data on winds and currents in order to aid shipping activity to early detection of harmful algal blooms. Environmental information is essential for research, including modeling and developing forecasting capabilities, but there is limited information available for much of the southeast. Existing measurements such as those made by the National Coastal Assessment, the National Estuarine Research Reserves and SECOORA should continue, as should the more traditional state monitoring programs. However, there is a need for more robust monitoring of nearshore areas (e.g., surf zone, tidal zone, and estuaries). One approach would be to develop a tiered strategy for monitoring that can be used to characterize systems at a broad scale, which can then be followed with targeted sampling in problem areas. Parameters that would be useful to measure include currents, turbidity, surface waves, water levels, wind conditions, pH, harmful algal blooms, pathogens, nutrient concentrations, and chemical contaminants. However, techniques to monitor some of these are still not available.

- **Develop detection techniques for pathogens and contaminants** – Information on pathogen and contaminant concentrations is important for resource managers, particularly with respect to those substances that pose a threat to human health. There are several emerging chemicals of concern, such as pharmaceuticals and other persistent organic pollutants, which are not well studied in terms of their potential effects on ecosystems. Real-time techniques need to be developed to indicate and quantify the presence of human pathogens such as fecal coliforms and viruses. Apex predators may serve as sentinel species for monitoring pathogen and contaminant concentrations. Issues related to marine debris, are also a concern, particularly microplastics, which can concentrate contaminants in organisms.

- **Identify sources of pollutants to coastal waters** – There is a need to identify the sources of both point and non-point pollutants (e.g., microbial pathogens, nutrients, metals, polycyclic aromatic hydrocarbons) and to relate these inputs to coastal water quality. The type of information needed includes data on upstream land use, percentage of impervious cover, amount of runoff, concentrations of pollutants in the inflow, and residence times of the receiving waters. Atmospheric sources are also important for some pollutants (e.g., mercury). Studies are needed to evaluate how different land use practices affect downstream loading. For example, how do small changes in fill, changes in vegetation cover, or different building styles affect runoff and sedimentation? What are the sources of pathogens that result in closures of beaches and shellfish beds?

- **Develop coupled biological/physical models for the region** – Coupled biological/physical models are useful for synthesizing information about current conditions, evaluating hypotheses about the relative importance of different forcing mechanisms, and forecasting. Coupled models for the coastal ocean would provide information about circulation patterns, coastal upwelling, and the movement of nutrients

[30] Note that these were all identified as high priority needs and are presented without further ranking.

and pollutants in the area. They could also be used to evaluate alternative scenarios and project climate and weather impacts such as drought, changes in the quality and amount of freshwater inflow, and flooding.

- **Assess the implications of land use change** – Humans modify the environment in myriad ways, from building houses and roads along beaches and marshes to dredging channels for boating and navigation. The cumulative impacts of these activities are not clear, and we do not understand the feedbacks between human and natural systems (e.g., how do changes in beach quality affect property values?). Studies are needed to evaluate these interactions. For example, how are ecosystem services affected by increasing human population density and development along tidal creeks? Are we losing important spawning habitat as a consequence of land use change? Is there a carrying capacity for humans in the Southeastern coastal zone? How can land use change be managed to minimize deleterious effects on natural resources?

- **Evaluate the sources, transport, and fate of sediments** – Sediments in coastal waters can come from upland sources such as rivers, from shoreline erosion, from internal biological processes, or from the ocean. Once sediment enters a system it can go through multiple cycles of settling and resuspension by tidal currents and storm events. Sediment input is important for maintaining tidal wetlands, but high concentrations in the water can reduce light availability for primary producers (particularly benthic producers such as sea grasses). Sediments can also have high concentrations of metals and organic contaminants, which can affect benthic organisms as well as the quality of the overlying water. There is a need for studies on the flux of sediment to coastal areas (is sediment supply adequate for maintaining salt marsh elevation relative to sea-level rise?), for information on where it tends to accumulate (where are the hot spots for water quality problems?), and for models of sediment transport (how is sediment movement affected by wind or boat traffic?). This information is also important when considering dredging and disposal activities.

Disaster-Resilient Communities

The southeastern coastal region, like many coastal areas, faces many challenges presented by hazards such as hurricanes and coastal storms as well as pressures from rising sea levels and increasing ocean temperatures related to climate change. The goal of disaster-resilient communities is to be able to absorb and rebound from changes or shocks to both the built and natural environment caused by these extreme events. An important component of this topic is to understand the potential risks and take steps to prepare and adapt before disasters occur.

Coastal areas are subject to hurricanes and other storms as well as the effects of waves and wind. In recent years, numerous hurricanes have hit the southeastern coast, including Hurricane Isabel in 2003; Hurricanes Gaston, Alex, Francis, Jeanne, Ivan and Charley in 2004; and Hurricanes Dennis, Katrina, Rita, Wilma and Ophelia in 2005 (not to mention earlier storms, such as Fran in 1996 and Dennis in 1999). Hurricanes cause property damage to coastal communities and can also dramatically alter the shoreline (e.g., Hurricane Isabel cut two new tidal inlets near Cape Hatteras). The effect of waves and wind is a constant challenge for coastal areas, particularly in exposed areas. A U.S. Geological Survey assessment of shoreline change[31] found that rates of erosion for the region were highest along barrier islands and headland shores associated with the Santee delta of South Carolina. Erosion was also rapid along some barrier islands in North Carolina. These natural processes influence and can be exacerbated by human actions. Coastal erosion is influenced by dredging, shoreline stabilization efforts (e.g., groins and seawalls), sand mining, and beach renourishment.

Hazards also emerge as a result of the effects of climate change, albeit over longer time frames. Sea level is inexorably rising along many of the low-gradient coastal plain environments of the world, and the rate of sea-level rise is expected to increase over the coming decades as higher global temperatures accelerate both glacial melting and expansion of ocean and coastal waters. In the southeast, sea level has risen approximately 0.3 cm/year between 1950 and 1999 (Zervas 2001). Low-lying intertidal areas are particularly sensitive to these changes, because only slight variations in vertical position can affect large parts of the landscape species composition. Coupled with increased sea level is a predicted increase in intensity of tropical storms (Karl et al. 2009). Hurricane strength is predicted to increase, with increased peak wind speeds, rainfall intensity, and storm surge height and strength (Karl et al. 2008). Even without additional coastal development, storm surge levels and hurricane damages are likely to increase due to increasing hurricane intensity (Gutowski et al. 2008). In an assessment of the entire southeast region (including the southeastern and Gulf of Mexico states), the U.S. Global Change Research Program concluded "sea level rise and the likely increase in hurricane intensity and associated storm surge will be among the most serious consequences of climate change" (Karl et al. 2008).

The SARRP *Stakeholder Survey* identified several high priority issues explicitly relevant to Disaster-Resilient Communities, including an increase of erosion and potential changes in shoreline and habitats due to sea-level rise. An additional, related impact (the effects of shoreline hardening on coastal resiliency capacity) was identified in the open section of the

[31] US Geological Survey, Center for Coastal And Watershed Studies, Open File Report 2005-1401. 2005. Morton, R. and T. Miller. *National Assessment of Shoreline Change: Part 2. Historical Shoreline Changes and Associated Coastal Land Loss Along the U.S. Southeast Atlantic Coast.* 40pp.

survey. The SARRP *Needs Assessment* identified the following research topics associated with these issues: the role of the ocean with respect to long-term global climate change; modeling for hazard preparation (e.g., storms, hurricanes, erosion, oil spills); evaluation of erosion prediction methodologies for identification and management strategies; best mitigation practices to address effects of climate change; and development of ocean models integrating the best models of ocean processes.

The high priority research topics related to Disaster-Resilient Communities are[32]:

- **Assess vulnerability to natural hazards** – Hurricanes, tsunamis, and other storms (e.g., nor'easters) can re-shape the coast and cause significant property damage. Chronic changes such as sea-level rise, shoreline erosion or changes in freshwater and sediment delivery can also affect coastal areas. There is a need to evaluate the vulnerability of the southeast region to these hazards, in terms of both its physical and human dimensions. Is shoreline erosion increasing as a consequence of human alteration? Which areas are most vulnerable to storms or sea-level rise due to their location and their geomorphology? Which areas are most vulnerable due to their population density and the location and resilience of their built infrastructure? How do these two areas overlay? Although this information is available for some areas, a region-wide assessment is lacking.

- **Develop coastal inundation models –** Coastal inundation models are important for predicting the effects of storms, increases in sea level, and the effects of upland changes such as building sea walls and changing freshwater inflow. Although there are numerous types of models available, there is a need for an integrated assessment and validation testing of these models at scales that are relevant for regional resource management, planning, and decision-making. It is also important to acquire high precision topobathy for sea-level/flooding predictions (which is also necessary for accurate circulation models). Observations of wind, currents, and other environmental conditions that can be obtained from an offshore observing network are also important components for model verification.

- **Evaluate adaptation strategies** – Adaptation involves making "adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes…" (Adger et al. 2007). Although there are several ongoing adaptation efforts, studies are needed to evaluate the effectiveness of potential adaptation or mitigation strategies. What are the options for reducing vulnerability or increasing resilience of coastal communities to hazards such as flooding, hurricanes, and erosion in the southeast? Should a community purchase low-lying areas that are likely to transform into intertidal marsh in response to rising sea level? What are the potential physical, societal, and economic consequences of different strategies? Answering these questions will require engineering studies on the resilience of coastal infrastructure to natural disasters. This type of research is especially important in light of climate change and the potential for increased intensity of storms, increased inundation, and changes in water supplies. An evaluation of the obstacles to implementing adaptation strategies should also be

[32] Note that these were all identified as high priority needs and are presented without further ranking.

conducted: why are we not using information on vulnerability to promote or implement adaptation?

- **Develop economic models for hazards** – Models that predict changes in the response of the physical environment provide information on how an area might be inundated or whether a structure is at risk to a storm event. However, studies are needed to evaluate the economic consequences of these events. Additional studies are also needed to link those predictions with information on the economic consequences of different policy options. For example, what are the economic effects of changing beach renourishment practices? What is the cost-benefit of armoring versus retaining natural shorelines? How might changes in flood insurance policies affect coastal development and the relative economic risks due to hurricanes?

- **Assess people's perceptions, at a regional scale, regarding the risk of living/buying on the coast** – In order to design effective education, outreach and extension programs on this issue, it is first necessary to conduct research to identify residents' perceptions of risk. Results of that research can guide the degree to which outreach is focused initially on education versus some type of community-based social marketing. For example, if residents are aware of hazards including storm surge and sea-level rise but are not motivated to take action, social science research may be useful in identifying the reasons for this disconnect. Conversely, if they are not well informed regarding the economic, safety, and quality-of-life related risks of living along the coast, a primary focus may be education. A carefully designed social science research project that includes formal surveys and focus sessions is needed to address this issue, and to identify regional differences in knowledge and motivation so that programs can be locally tailored.

- **Assess cultural resources in coastal communities and include them in resource planning** – The southeast is rich in archeological and historic sites, ranging from Native American middens to Revolutionary and Civil War era buildings to shipwrecks (e.g., the "Graveyard of the Atlantic" in NC) and other submerged artifacts. The region's diverse cultural heritage, epitomized by vibrant communities such as the Gullah-Geechee (along coastal SC and GA), Hog Hammock (GA) and American Beach (FL) have retained their languages, practices, and unique cultural histories. There is a need to develop research and informational partnership efforts to identify and ameliorate the threats to these populations. There is also a need for comprehensive assessments and mapping of these living and historic resources. For example, what is their vulnerability to coastal hazards including sea-level rise?

Discussion

The South Atlantic Regional Research Project is a regional, multi-agency project to develop a plan for coordinated coastal and ocean research in the southeastern U.S. The research priorities presented in this document are the result of a three-year process that involved an extensive network of scientists and managers from federal and state agencies, regional organizations, and academic institutions, with stakeholder input from public, private and nongovernmental constituents. It is our hope that the research areas identified by this effort will be useful for the scientific community, funding agencies and other groups interested in addressing high priority regional needs.

In addition to aligning with the themes of the Governors' South Atlantic Alliance (SAA), the research needs identified in this plan are also in keeping with the National Ocean Council's current "Priority Objectives".[33] They include priorities that address Ecosystem-based management; Coastal and Marine Spatial Planning; regional ecosystem protection and restoration; water quality and sustainable practices on land; ocean, coastal, and Great Lakes observations and infrastructure; and resiliency and adaptation to climate change. The SARRP priorities are also consistent with the National Sea Grant focus areas (Safe and Sustainable Seafood Supply, Sustainable Coastal Development, Healthy Coastal Ecosystems and Hazard Resilience in Coastal Communities) as well as the priority objectives of the NOAA Coastal Strategy (coastal hazards and climate change, competing coastal uses and habitat loss, and coastal pollution and human health effects).

There is growing recognition of the importance of regional-scale coordination of coastal activities. In addition to Sea Grant's regional research planning efforts (SARRP is one of ten regional initiatives being conducted across the U.S. and the Insular Pacific), there are regional ocean partnerships in most areas of the country, analogous to the SAA. The dynamic partnerships that have been fostered by the SARRP project, and the research priorities plan itself, provide a solid foundation for these proposed activities.

There are many reasons to be optimistic about the utility of this plan, due in large part to SARRP's strong partnerships with key agencies in the region. Throughout our three-year process, committed resource professionals, agency staff and academic scientists have consistently invested their time and resources to cooperate in the development of a regional plan addressing critical coastal and ocean priorities. We have also been approached by several investigators interested in aligning their proposed work with SARRP research priorities. One of our most important partners is the SAA, which is working to increase regional collaboration to sustain and enhance the four states' missions involving coastal and marine environments with respect to natural resources, economics, public safety, social welfare and national defense. The draft SARRP results were provided to the Alliance as a resource document as they developed their Regional Action Plan, and is thus in place to inform the research component of that process as it moves forward.

[33] http://www.whitehouse.gov/administration/eop/oceans/objectives

The next step in the SARRP process is to share the research plan broadly with other organizations, institutions, agencies and researchers whose effort will be necessary to carry out this work. Numerous existing groups in the region, including SECOORA, COSEE-SE, the National Estuarine Research Reserves, Sea Grant, and Sea Grant Extension, have robust outreach components, ensuring that the plan will reach a wide variety of potential end-users. In addition, the SARRP Regional Advisory Group, instrumental in the production of the plan, will continue as an informal network to encourage individual investigators to address these priorities and to explore coordinated funding opportunities.

To further facilitate the plan, we have collected information describing ongoing or planned activities that are relevant to each priority and have identified research topics specifically aligned with the missions of particular agencies and organizations. The Strategy Team workshop also identified opportunities for policy, education and outreach (Appendix D). We are currently working to identify potential collaborative projects that support the regional-scale research priorities described in this report. The SARRP plan provides a strong foundation for coordinated research, and the network of institutions and individuals that produced the plan will serve as an on-going platform for coordination, collaboration, and resource sharing in the southeastern region.

Acknowledgements

We wish to thank the many individuals who have participated and assisted in the success of this project, including the members of the Regional Advisory Group and additional Strategy Team members, all of whom volunteered their time for this effort. We thank the National Sea Grant Office, and the coordinators and staff of the other Sea Grant Regional Plans (especially in the Gulf of Mexico, Mid-Atlantic, and the West Coast) for their advice and guidance. The NOAA Coastal Services Center was invaluable in helping to plan for a successful Strategy Team Workshop. Heidi Recksiek and Lynne Betzhold of the Coastal Service Center, along with Courtney Tobin of the UGA Fanning Center, also lent us their expert services as facilitators at that meeting. We also received help from the staff in the Sea Grant offices of each of the four southeastern Atlantic states (including Ginger Garrison, Dianne England, Jack Thigpen, and intern Megan Knott) and the Georgia Coastal Research Council (especially Janice Flory and John Carpenter). We appreciate the support of the Governors' South Atlantic Alliance Executive Planning Team members (particularly Chris Russo and Ginny Fay), with whom we have fostered a strong partnership. Cassandra Drennon provided valuable input on structuring the stakeholder survey. We also thank the many stakeholders who responded to our survey as well as the people who reviewed earlier drafts of this document (in particular, Roger Pugliese, David Whitaker and Fred Holland). This project was supported by NOAA Grant #NA06OAR4170205.

Appendix A

SARRP Organizing Committee

North Carolina Sea Grant
Steve Rebach, Associate Director
Michael Voiland, Executive Director

South Carolina Sea Grant Consortium
M. Richard Devoe, Executive Director
Denise Sanger, Assistant Director for Research and Planning

Georgia Sea Grant
Chuck Hopkinson, Executive Director
David Bryant, Assistant Director

Florida Sea Grant
Karl Havens, Director
Mike Spranger, Associate Director for Extension and Education

Georgia Coastal Research Council
Merryl Alber, Director, Georgia Coastal Research Council. Marine Sciences, Univ. of Georgia
Christine Laporte, Program Coordinator, GCRC, Marine Sciences, University of Georgia

Appendix B

SARRP Regional Advisory Group Membership
(Core Strategy Team)

Federal Agencies

National Oceanic and Atmospheric Administration:

- National Sea Grant - Terry Smith
- Coastal Services Center - Jeff Payne
- National Estuarine Research Reserve System - Rebecca Ellin, Manager, NC Coastal Reserve Program

South Atlantic Fishery Management Council - Roger Pugliese

U.S. Geological Survey - Jack Kindinger, Associate Director, Florida Integrated Science Center Coastal and Watershed Science Team

U.S. Environmental Protection Agency - Thomas L. Baugh, Scientist Liaison Region IV

U.S. Army Corps of Engineers - Brian Williams, Coastal Engineer

National Park Service - Joe DeVivo, Coordinator, Southeast Coast Network

U.S. Fish and Wildlife Service Region IV - John Galvez, Project Leader, South Florida Fisheries Resources

Federal Emergency Management Administration, Dept. of Homeland Security - Stephanie Madsen, Deputy Regional Environmental Officer, Region IV

U.S. Department of Agriculture Natural Resources Conservation Service – Kale Gullett, Regional Fisheries Biologist

Regional Partners

South Atlantic Alliance (SAA) - Chris Russo, North Carolina Department of Environment and Natural Resources

Southeast Regional Partnership for Planning and Sustainability (SERPPAS) - Chris Russo (ibid)

Southeast Aquatic Resources Partnership (SARP) - Scott Robinson, Georgia Department of Natural Resources

Southeast and Caribbean Regional Team (SECART) – Geno Olmi, National Oceanic and Atmospheric Administration – Coastal Services Center

Southeast Coastal Ocean Observing Regional Association (SECOORA) – M. Richard Devoe, South Carolina Sea Grant Consortium

State Agencies

North Carolina

Department of Environment and Natural Resources:

- Division of Coastal Management - Steve Underwood, Assistant Director, Policy & Planning
- Division of Marine Fisheries - Louis Daniel, Director. Alternate: Michelle Duval, Executive Assistant for Councils
- Division of Water Quality - Jimmie Overton, Branch Chief, Environmental Sciences Section. Alternate: Peter Caldwell, Supervisor, Intensive Survey Unit

South Carolina
Department of Natural Resources:

- Marine Resources Division - David Whitaker, Assistant Deputy Director
- Marine Resources Research Institute - Bob Van Dolah, Director

Department of Health and Environmental Control:

- Ocean and Coastal Resource Management - Braxton Davis, Director, Science and Policy. Alternate: Elizabeth B. von Kolnitz, Director of Coastal Planning
- Water Quality Division - M. Rheta Geddings, Assistant Bureau Chief, Bureau of Water

Georgia
Department of Natural Resources:

- Coastal Resources Division: Brad Gane, Assistant Director for Ecological Services
- Department of Community Affairs: Jim Frederick, Director, Office of Planning and Quality Growth. Alternate: Adriane Wood

Florida
Department of Environmental Protection: Ellen McCarron, Deputy Director, Coastal and Aquatic Managed Areas (CAMA). Alternate: Lee Edmiston, Director CAMA
Florida Fish and Wildlife Conservation Commission - Gil MacRae, Director Fish and Wildlife Research Institute. Alternate: Henry Norris, Section Leader

Academic
Southern Association of Marine Laboratories - Dr. Jim Sanders, Director, Skidaway Institute of Oceanography. Alternate: Clark Alexander, Professor, Skidaway Institute of Oceanography

Appendix C

Additional SARRP Strategy Team Members

Federal Agencies

National Oceanic and Atmospheric Administration (NOAA)
Billy Causey, Southeast Regional Director, National Marine Sanctuaries Programs
Chris Ellis, Sociologist, Coastal Services Center
Dwayne Porter, Centralized Data Management, National Estuarine Research Reserves
Susan White, National Centers for Coastal Ocean Science, Hollings Marine Laboratory

U.S. Fish and Wildlife Service
Tripp Bolton, Fisheries Biologist

U.S. Geological Survey
Dennis Krohn, Geologist, Center for Coastal and Watershed Studies

Academic

Social Sciences
Chuck Adams, Marine Economist, Florida Sea Grant
Tom Ankerson, College of Law, University of Florida
Bob Bacon, Extension Program Leader, South Carolina Sea Grant Consortium
Allen Burns, Executive Director, Coastal Georgia Regional Development Center
David Griffith, Department of Anthropology, East Carolina University

Natural and Physical Sciences
Arindam Chowdhury, Director, Laboratory for Wind Engineering Research, International Hurricane Research Center, Department of Civil and Environmental Engineering, Florida International University
Paul Gayes, Director, Center for Marine and Wetland Studies, Coastal Carolina University
Patrick Jodice, Unit Leader, South Carolina Cooperative Fish and Wildlife Research Unit, Department of Forestry and Natural Resources, Clemson University
Peter Sheng, Professor, Coastal and Oceanographic Department, Civil and Coastal Engineering University of Florida
Amy E. Wright, Director, Center for Marine Biomedical and Biotechnology Research, Harbor Branch Oceanographic Institute, Florida Atlantic University

Ports Authorities

Hope Moorer, Program Manager, Navigation Improvement Projects, Georgia Ports Authority

Regional Non-Governmental Organizations

Angela Bliss, Center for Ocean Sciences Education Excellence - Southeast
Mary Conley, Southeast Marine Conservation Director, The Nature Conservancy

Appendix D

Policy and Education & Outreach Needs Identified during Strategy Team Workshop

Policy

- Conserve land critical for preservation in the face of climate change (e.g., shifting species and habitats)
- Develop metadata and data collection standards
- Designate marine development zones
- Improve seafood labeling to denote origin and ensure safety and accurate representation of products
- Provide affordable housing for workers
- Develop land use protection strategies for preserving working waterfront uses
- Facilitate access to new technologies that allow monitoring and observing
- Determine appropriate mix of federal and non-federal resources to effectively monitor coastal resources
- Provide avenues for the use of private sector data to inform research (e.g., marine operations)
- Encourage cooperation among regional ports
- Modify insurance policies based on sea-level rise/ who is bearing the risk
- Develop integrated land and water management policy for coastal margins
- Evaluate ways to initiate response to hazards when risk is low and cost vs. benefit is high

Education & Outreach

- Find ways to enhance the public's appreciation of coastal resources
- Increase awareness of the value of ocean exploration
- Increase awareness of microbial effects on humans (e.g., Vibrio species)
- Teach people how to better judge risk of contaminants and other pollutants
- Use volunteers/folks already on the water to help with monitoring and observing
- Provide education about non-market valuation
- Develop educational materials on ways to abate pollution at marinas (e.g., new bottom paint)
- Provide better explanations of consumption advisories vs. benefits of seafood
- Develop strategies for engaging diverse audiences in discussions about climate change (enhance climate extension activities)
- Develop visualization tools to translate the results of research activities
- Evaluate the ways in which research results translates to changes in behavior and investment activities
- Foster communication with elected officials to support ocean observation science and data use

Literature Cited

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. 2007. Assessment of adaptation practices, options, constraints and capacity. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.). Cambridge University Press, Cambridge, UK. pp. 717-743

Arthur, C., J. Baker and H. Bamford (eds.). 2009. Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris. Sept 9-11, 2008. NOAA Technical Memorandum NOS-OR&R-30.

Beck, M.W., R.D. Brumbaugh, L. Airoldi, A. Carranza, L.D. Coen, C. Crawford, O. Defeo, G.J. Edgar, B. Hancock, M. Kay, H. Lenihan, M.W. Luckenbach, C.L. Toropova, G. Zhang. 2009. Shellfish Reefs at Risk: A Global Analysis of Problems and Solutions. The Nature Conservancy, Arlington VA. 52 pp.

Bricker, S., B. Longstaff, W. Dennison, A. Jones, K. Boicourt, C. Wicks, and J. Woerner. 2007. Effects of Nutrient Enrichment In the Nation's Estuaries: A Decade of Change. NOAA Coastal Ocean Program Decision Analysis Series No. 26. National Centers for Coastal Ocean Science, Silver Spring, MD. 328 pp.

Dame, R., M. Alber, D. Allen, M. Mallin, C. Montague, A. Lewitus, A. Chalmers, R. Gardner, C. Gilman, B. Kjerfve, J. Pickney, and N. Smith. 2000. Estuaries of the South Atlantic coast of North America: their Geographic Signatures. Estuaries 23: 793-819

Environmental Protection Agency (U.S.). Office of Research and Development/Office of Water. 2008. National Coastal Condition Report III. Washington, DC. EPA-620/R-03/002. 329 pp.

Gutowski, W.J., G.C. Hegerl, G.J. Holland, T.R. Knutson, L.O. Mearns, R.J. Stouffer, P.J. Webster, M.F. Wehner, and F.W. Zwiers. 2008. Causes of observed changes in extremes and projections of future changes. In: *Weather and Climate Extremes in a Changing Climate: Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands*, Karl, T.R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (eds.). Synthesis and Assessment Product 3.3. U.S. Climate Change Science Program, Washington, DC. pp. 81-116.

Karl, T. R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (eds.). US Climate Change Program. 2008. *Weather and Climate Extremes in a Changing Climate*. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Executive Summary. Department of Commerce, NOAA's National Climatic Data Center, Washington, DC. USA, 164 pp.

Karl, T.R., J.M. Melillo, T.C. Peterson, (eds.). 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press, UK. 188 pp.

National Oceanic and Atmospheric Administration National Marine Fisheries Service. 2006. Fisheries Economics of the US. Economics and Sociocultural and Trends Series; South Atlantic Summary. Wash. DC. pp 93-111

Obama, Barack. 2010. Stewardship of the Ocean, Our Coast, and the Great Lakes. Exec. Order No. 13,547, 75 Fed. Reg. 43,023 Washington DC. 7 pp.

Pew Oceans Commission, 2003. "America's Living Oceans; Charting a Course for Sea Change. A report to the Nation, Recommendations for a New Ocean Policy. Washington, DC. 166 pp.

S.C. Department of Parks, Recreation and Tourism and S.C. Golf Course Owners Association March 2002. 2000/2001 Economic Impact of Golf in South Carolina. 15 pp.

United Nations Educational, Scientific and Cultural Organization. 2006. A Handbook for Measuring the Progress and Outcomes of Integrated, Coastal and Ocean Management. IOC Manuals and Guides. 46 pp.

Verity, P.G., M.L. Alber, and S.B. Bricker. 2006. Development of hypoxia in well-mixed estuaries in the Southeastern USA. Estuaries and Coasts 29: 665-673.

Zervas, C. 2001. *Sea Level Variations of the United States 1985-1999*. NOAA Technical report NOS CO-OPS 36. NOAA. Silver Spring. MD. 66 pp.